Title Page

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A Novel Streamlined Trauma Response Team Training Improves Imaging Efficiency for Pediatric Blunt Abdominal Trauma Patients.

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INTRODUCTION

Trauma is the leading cause of morbidity and mortality among people ages 1 to 19 years. There are more than 12 million children affected by trauma annually, and more than 10,000 deaths per year [1 2]. Expeditious assessment, diagnosis and management of bluntly injured pediatric patients is essential to minimize morbidity and mortality. Efficient trauma response is a major determinant of the quality of trauma care; therefore, the time interval from patient arrival to provision of care is an important metric at pediatric trauma centers.

Complementary to an organized and efficient well-performed primary and secondary survey, the management of acute or complex trauma commonly involves radiologic evaluation, including Computed Tomography (CT) and Focused Assessment with Sonography for Trauma (FAST). Therefore, timely use of imaging studies can improve outcomes through faster injury recognition during trauma evaluations [3 4].

A well-organized trauma response team significantly increases survival rate after major trauma and improves the efficiency of care, evidenced by statistically shorter times from arrival to CT scan, operating room, and reduced total time in the ED in the adult population[4]. Previous research shows that implementation of a high fidelity, multidisciplinary simulation directed at trauma response team members can improve patient outcomes during trauma resuscitations [4 7]. It is well established that simulation training not only improves the confidence level of providers in life-saving procedures, but also promotes better teamwork, communication, and patient outcomes [8]. In 2014, Norton Children's Hospital/University of Louisville instituted a trauma response team training that streamlined the approach to pediatric trauma by emphasizing trauma team dynamics to improve the quality and efficiency of acute pediatric trauma management. Prior to the training, there was a dedicated trauma response team but no specific process for trauma evaluations. All providers, nurses and ancillary staff were required to complete the training, which was taught through a hands-on simulation.

Since timely multidisciplinary response and appropriate use of imaging is important to patient outcomes [7], the goal of this project was to improve various ED metrics, which serve as an indirect measure of quality of care, after the implementation of a streamlined trauma response team approach. While prior studies showed that a trauma response team reduces the time required for initial assessment and improved outcomes among pediatric trauma patients, there is a lack of literature on the effect of a streamlined trauma response team with specific roles on the acquisition of imaging studies in pediatric trauma patients [3 4].

METHODS

Study Design

This study is a retrospective chart review of electronic medical records and trauma registry data from Norton Children's Hospital before and after the implementation of a streamlined trauma response team. Assessment of the implementation effect was conducted over a 27-month period. This study was approved by the University of Louisville Institutional Review Board.

Setting

Norton Children's Hospital (NCH) is an American College of Surgeons (ACS) verified Level 1 Pediatric Trauma Center in Northern Kentucky with about 60,000 annual ED visits. It is a freestanding children's hospital providing emergency, inpatient, and ambulatory care to children in Kentucky and Southern Indiana. The NCH ED manages a wide array of traumatic injuries, using a two-tiered triage approach with the highest level of activation as a Trauma Stat (level 1) and second tier as a Trauma Alert (level 2). Trauma activation mobilizes the ancillary and subspecialty resources that are necessary to acutely assess and manage moderate to severely injured pediatric trauma patients.

The trauma team at NCH consists of ED physicians, pediatric surgeons, residents, respiratory therapists, ED nurses, radiology technicians, anesthesiologists, pharmacists and chaplains. The decision to activate the trauma team and the designation of trauma activation is determined by the Pediatric Emergency Medicine (PEM) physician or PEM fellow prior to the patient's arrival using the emergency medical services (EMS) verbal report and/or recommendations based on Advanced Trauma Life Support (ATLS) guidelines provided by the American College of Surgeons (ACS). The role identification at the NCH ED for trauma management prior to development of the trauma response team was limited to the team leader, which was a pediatric surgery attending, pediatric surgery fellow, a PEM attending, or a PEM fellow. This often led to confusion with assisting physician and nursing roles, resulting in slower evaluations, longer times to imaging and laboratory studies, delayed identification of injuries, and prolonged time to definitive care and disposition.

Study Subjects

All trauma patients were managed according to an established protocol of trauma resuscitation. Documentation of trauma activation is stored in the NCH electronic medical record (EMR) system (Epic), with abstraction of data elements into a trauma registry. The EMR of charts identified as trauma team activations from the NCH Trauma registry were retrospectively reviewed to assess for change after implementation. Patient charts were included for bluntly injured children < 18 years with a trauma activation who had a CT scan. Excluded patients were those who were evaluated for burns or penetrating trauma since the focus was blunt pediatric trauma. Children who were transferred from another facility were excluded because often a trauma work-up had already been initiated or completed and therefore, imaging already obtained or a diagnosis established. Pediatric trauma patients who arrived by private vehicle were also excluded because their pre-hospital management and coordination of care may have been different than those who arrived via EMS.

Team Training

Simulated streamlined trauma response team training was conducted between April 1st 2014 to June 30th, 2014 with all trauma team physician leaders, ED nurses and ED ancillary staff. Rotating resident physicians of various specialties (pediatrics, surgery, family medicine, anesthesiology, emergency medicine) were trained at the start of their subsequent rotation in the ED and any new or untrained ED nurses or ancillary staff participated in these ongoing sessions. Health care professionals were not aware that any metrics would be measured after the implementation of the streamlined trauma response team approach.

The implementation of a streamlined trauma team approach offers an organized approach to trauma response with emphasis on role responsibility in a coordinated, efficient manner. It consists of strategic placement of each trauma team member with very specific responsibilities to fully utilize the function of the trauma room and various skill sets of each team member. In addition to the team leader, the trauma response team role assignments, which are directly involved with patient care, include an airway provider, procedure physician, assessing physician, primary and secondary nurses, and bedside nurse. Any other providers or staff members in the room must move away from the patient bedside unless asked to approach for assistance. The team leader coordinates the pre-arrival roles, and the primary and secondary surveys in sequential and timely fashion. One goal of the streamlined trauma response team approach is to complete all assessment, including necessary CT scans, of the patient in 30 minutes or less. Another goal is for FAST completion in less than 15 minutes from the time of arrival. The investigators used these metrics as indirect markers of efficiency for the streamlined trauma team approach. Following the initial training, all ED physicians, residents, nurses and staff are required to complete yearly trauma response team training.

Outcome measures

Various ED metrics for 12 months prior to implementation of a streamlined trauma response team were collected through chart review to determine baseline data. Patient charts were reviewed 12 months after the streamlined trauma response team training (July 1st 2014 to June 30th 2015). Chart review and data collection began after the completion of all the training sessions. For each patient chart, the following data were collected: basic demographic data (age, race, ethnicity, gender), mode of transportation to the ED, mechanism of injury, date and time of arrival to ED, time at initiation of CT scan, time at completion of FAST scan, time of disposition, and final disposition. The database was based on patient data as noted above matched to corresponding medical record number (MRN) identification. This list was used with the abstraction to guarantee that there was no duplicate data. Any missing data was added as needed during the abstraction.

The primary measure was ED arrival time to the time of the first CT image acquisition in the NCH radiology department. The time recorded for the first CT image was the time documented on the scout image, on the hospital's Picture Archiving and Communication System (PACS). Other ED metrics that were included in the analysis were the proportion of bedside FAST exams in children with blunt trauma, and in those who had a FAST exam, ED arrival time to the time of completion of the scan. The time stamp of FAST/E-FAST completion was based on the documentation in the patient ED course timeline. The same exclusion criteria were used, however all pediatric blunt trauma patients, regardless of CT scan acquisition, were included in the FAST/E-FAST metrics. The time to disposition to OR and ICU were also analyzed.

Data collection and analysis

Patient demographics between the pre-implementation and post-implementation groups were analyzed using chi-square to determine if the groups were similar. The median time to CT scan and the median time to FAST scan between the pre-implementation and post-implementation groups were placed on a run chart over the study period to determine if the intervention resulted in an improvement in these metrics. The proportion of FAST scans was also placed on a run chart to look for improvement in this measure.

Effect size was calculated at varying standard deviations. The goal was the detection of a 10-minute change with a power of 0.9, and an alpha of 0.05, requiring a minimum sample size of 22 cases per group. Medians were used to compare: 1) time to CT scan; and 2) time to FAST 3) time to disposition between the pre-choreography and post-choreography training groups. A Chi

Squared test was used to compare the proportion of completed FAST exams in the pre-implementation group to the post-implementation group.

RESULTS

There were 928 total patient charts from the NCH trauma registry that were reviewed. After the inclusion and exclusion criteria were met, 210 charts were included in the pre-implementation group and 203 charts were included in the post-implementation group when evaluating for changes in time to CT scan acquisition (Figure 1). The number of charts with FAST scans completed in the pre-implementation group was 315 and 337 in the post-implementation group (Table 2).

Patient demographics showed no significant difference in age group, gender, race, or ethnicity between the two groups (Table 1). The majority of the trauma designations were Trauma Alerts (level 2) and most of these patients were admitted for further management, which showed no significant difference between the pre and post implementation groups (Table 1). The median injury severity score (ISS), the percentage of patients admitted directly to the operating room (OR) for surgical intervention, and the percentage of patients admitted to the ICU was also similar in both groups. The similarities in the ISS, ICU admission rate and OR rate suggest no significant variation in patient acuity and/or injury severity between the groups. However, the median time to OR in both level 1 and level 2 bluntly injured trauma patients decreased following the intervention (Table 3). The median time to ICU transfer increased in the level 1 trauma patients and decreased in the level 2 trauma patients following the intervention (Table 3).

Prior to implementation of a streamlined trauma response team approach, median door to CT time was 37 minutes compared to 28 minutes after its implementation (Figure 2; Table 2).

As shown in figure 2, the run chart shows a trend towards improvement with time during the post-implementation group. When further analyzed by trauma level, the median time to CT decreased from 35 minutes to 27 minutes and from 37 minutest to 32 minutes in level 1 and level 2 trauma respectively. The types of CT scans included brain, face, cervical spine, chest, thoracic spine, lumbar spine, and CTA of the neck, which were also similar in individual numbers between the two groups. The number of abdomen/pelvis CT studies decreased in the post-implementation group.

The proportion of FAST exams completed prior to implementation of a streamlined trauma response team approach was 66.3% and 86.8% in the post-implementation group. The run chart in figure 3 shows overall improvement as time progressed during the study period (Figure 3; Table 2). In the patients who had FAST/E-FAST examinations, the proportion of abdomen/pelvis CT scans decreased from 42.6% to 21.1% ($p < 0.05$). The proportion decreased from 44.4% to 38.1% and 43.3% to 18.8% in level 1 and level 2 trauma respectively. The patients who received FAST examinations were further analyzed to determine if the time to scan changed with the implementation of the streamlined approach. The pre-implementation group had a time to FAST scan of 18 minutes compared to 8 minutes after implementation (Figure 4; Table 2). In patients with a completed FAST/E-FAST, the median time to CT decreased from 38 minutes to 31 minutes. In those patients who did not have a FAST/E-FAST, the median time to CT decreased from 33 minutes to 27:30 minutes.

DISCUSSION

There are many trauma facilities that are not in compliance with ACS Committee on Trauma best practices, leading to inconsistent quality of trauma care[2]. A previous study showed that of 55 trauma centers, only one was compliant with the outlined 32 practice protocols and half were compliant with only14 of them [9]. Variable compliance by trauma facilities with recommended best practices and protocols results in variable outcomes. Likewise, prior to the implementation of this streamlined approach, trauma response at this facility often led to slow and disorganized primary and secondary trauma survey and subsequent patient disposition. The streamlined trauma response team approach in this study follows the ACS guidelines for the acute management of level 1 and level 2 trauma, and also shows that this approach decreases the time to CT, FAST completion, and transport to OR which were used as indirect markers of efficiency.

In both the pediatric and adult trauma population, CT scans are considered an important reference standard for the diagnosis of intracranial and torso injuries, which can affect the outcome of trauma morbidity and mortality [10 11]. While many studies looking at trauma outcomes have been conducted in adults, Vernon et al showed that the creation and implementation of a trauma team had a direct association on the time required for ED treatment of severe pediatric trauma and predicted survival in these patients [4]. Their study showed an average time to CT of 27 minutes in level one trauma patients [4]. Similarly, our data showed that after the implementation of a streamlined trauma response team, our trauma response efficiency as determined by time to CT improved significantly due to a more proficient primary and secondary assessment, resulting in faster transport to diagnostic imaging. This was under the pre-determined goal of 30 minutes, further confirming the effectiveness of an organized approach to severely injured pediatric trauma patients. Additionally, the higher acuity, level one trauma activations had lower times for CT and FAST acquisition, which is consistent with previous literature [4]. Lastly our data also showed a decreased time to OR, and thus definitive management, following the intervention.

The use of bedside FAST scans has become a standard of care in adult trauma and is gaining popularity in pediatric trauma. Utilizing this tool as a measure of work flow efficiency, this study also shows that the time to FAST/E-FAST scan in pediatric trauma improved significantly after the implementation of a streamlined trauma response team approach. Even more so, using this tool did not affect efficiency measures when evaluating time to CT scan. As such, the pre-determined goal for FAST completion at our institution was 15 minutes or less, which was based on the suggested time to completion of the secondary survey as an additional marker of efficiency for pediatric trauma evaluation [2]. The improvement in efficiency after implementation achieved this goal during the secondary trauma assessment.

Recent literature show that the use of FAST scans in the pediatric trauma population can safely decrease abdominal CT use [6] and the request/order for an abdomen/pelvis CT scan by surgeons decreases once a negative FAST examination has been completed [12-14]. Although this study was not designed to determine if the use of FAST affected the acquisition of CT abdomen/pelvis, it is interesting that the increased frequency of FAST scans was significantly associated with a decrease in the use of abdominal/pelvic CT after the intervention. Further stratification by trauma level revealed the effect was more significant in the less severely injured patients (level 2 trauma) as previously suggested.

This was a chart review so there are limitations of this study. The ED provider may have not appropriately activated a trauma (either not activated or assigned an incorrect trauma level) based on the pre-hospital EMS report. This would have delayed the organization of the trauma response team, the assessment, and subsequent imaging studies. There may have been other factors that delayed transport to radiology, including IV access, difficult airway, necessary advanced procedures, cardiac arrest, or another patient in the CT scanner. However, these factors would be expected to be the same in the two groups and to not significantly affect the results. Lastly, the data collected is susceptible to information bias largely due its dependence on the documented times in the trauma event time line, which may have some variation from one recorder to another. However, members of the trauma team recording the timeline were trained per ED policy prior to and after the implementation of the streamlined trauma response team approach and therefore, any variations should be similar between the two groups.

CONCLUSION

In conclusion, the implementation of a streamlined trauma response team approach showed a decreased time to both CT and FAST/E-FAST scans in pediatric blunt trauma patients. Our results show the importance of a streamlined trauma response team approach in pediatric trauma, guided by ACS recommendations which focuses on improved efficiency through rapid image acquisition during the primary and secondary assessments. Such an approach ensures that the team is following the ACS guidelines/recommendations for the evaluation of trauma and results in prompt acquisition of necessary imaging studies and subsequently, the rapid identification of injuries and physician decision-making, evidenced by improved time to OR. Future directions will seek to evaluate the impact of the streamlined trauma response team approach on other outcomes markers of morbidity and mortality.

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Figure 1a: Patient charts included in review looking at improvement in time to CT scan acquisition. The focus was on Level 1 and 2 trauma patients who came in by EMS from the scene with blunt trauma. CT = Computerized Tomography; EMS = Emergency Medical Services; ED = Emergency Department.

Figure 1b: Patient charts included in review looking at improvement in time to FAST scan acquisition. The focus was on Level 1 and 2 trauma patients who came in by EMS from the scene with blunt trauma. CT = Computerized Tomography; EMS = Emergency Medical Services; ED = Emergency Department.

Figure 2: Run chart of Time to CT with the median of pre- and post-training implementation of a streamlined trauma response team. Each time point is represented by median time in minutes per month.

Figure 3: Run chart of proportion of FAST scans completed during pre- and post-training implementation of a streamlined trauma response team. Each point is represented by percent per month.

Figure 4: Run chart of Time to FAST with the median of pre- and post-training implementation of a streamlined trauma response team. Each time point is represented by median time in minutes per month.

Table 1: Comparison of demographic data between pre-implementation and post-implementation groups. Statistical significance is denoted by *p <0.05.*

	Pre-Implementation (n=210)	Post-Implementation (n=203)	P value
Age (years)			0.77
0-4	46 (21.9%)	49 (24.1%)	
5-11	64 (30.5%)	56 (27.6%)	
12-18	100 (47.6%)	98 (48.3%)	
Gender			0.47
Male	128 (61%)	117 (57.6%)	
Female	82 (39%)	86 (42.4%)	
Race			0.08
Black	45 (21.4%)	46 (22.7%)	
White	155 (73.8%)	137 (67.5%)	
Other	10 (4.8%)	20 (9.5%)	
Ethnicity			0.33
Hispanic	9 (4.3%)	15 (7.4%)	
Non-Hispanic	200 (95.2%)	186 (91.6%)	
Unknown	1 (0.5%)	2 (1%)	
Disposition			0.24
Home	58 (27.6%)	71 (35%)	
OR/PICU	62 (29.5%)	58 (28.5%)	
Ward	89 (42.4%)	72 (35.5%)	
Other	1 (0.5%)	2 (1%)	
Trauma level			1
Level 1	29 (13.8%)	28 (13.8%)	
Level 2	181 (86.2%)	175 (86.2%)	

Table 2: Comparison of median time to CT and FAST between trauma levels. Statistical significance is denoted by *p <0.05*.

Trauma Choreography					
Level 1 trauma cases					
Imaging	**Pre-Training (n)**	**Standard deviation**	**Post-Training (n)**	**Standard deviation**	**p-value**
Time to CT image	00:35 (29)	00:10	00:27 (28)	00:08	0.001
Time to FAST	00:20 (14)	00:07	00:08 (19)	00:04	<0.05
Level 2 trauma cases					
Time to CT	00:37 (181)	00:23	00:32 (175)	00:28	<0.05
Time to FAST	00:17 (104)	00:18	00:09 (121)	00:11	<0.05
Total Trauma cases					
Time to CT	00:37 (210)	00:23	28 (203)	00:27	<0.05
Time to FAST	00:18 (118)	00:15	00:08 (140)	00:10	<0.05

Table 3: Comparison of median time to disposition (General Ward, PICU and OR). Time denoted in hours/minutes (hh:mm). Statistical significance is denoted by *p <0.05.*

Disposition	Pre-Training (n)	Standard deviation	Post-Training (n)	Standard deviation	p-value
Level 1 trauma cases					
Time to General Ward	02:52 (5)	01:04	03:38 (1)	--	--
Time to PICU	01:22 (19)	01:43	01:53 (16)	01:13	0.505
Time to OR	01:20 (5)	01:11	01:14 (8)	00:26	0.592
Level 2 trauma cases					
Time to General Ward	03:04 (84)	01:25	03:12 (71)	01:49	0.630
Time to PICU	02:38 (26)	00:54	02:00 (18)	00:58	0.124
Time to OR	02:06 (12)	00:58	01:53 (16)	01:32	1.0
Total trauma cases					
Time to General Ward	03:04 (89)	01:24	03:12 (72)	01:49	0.528
Time to PICU	02:06 (45)	01:03	01:59 (34)	01:05	0.498
Time to OR	01:59 (17)	01:01	01:29 (24)	01:20	0.350

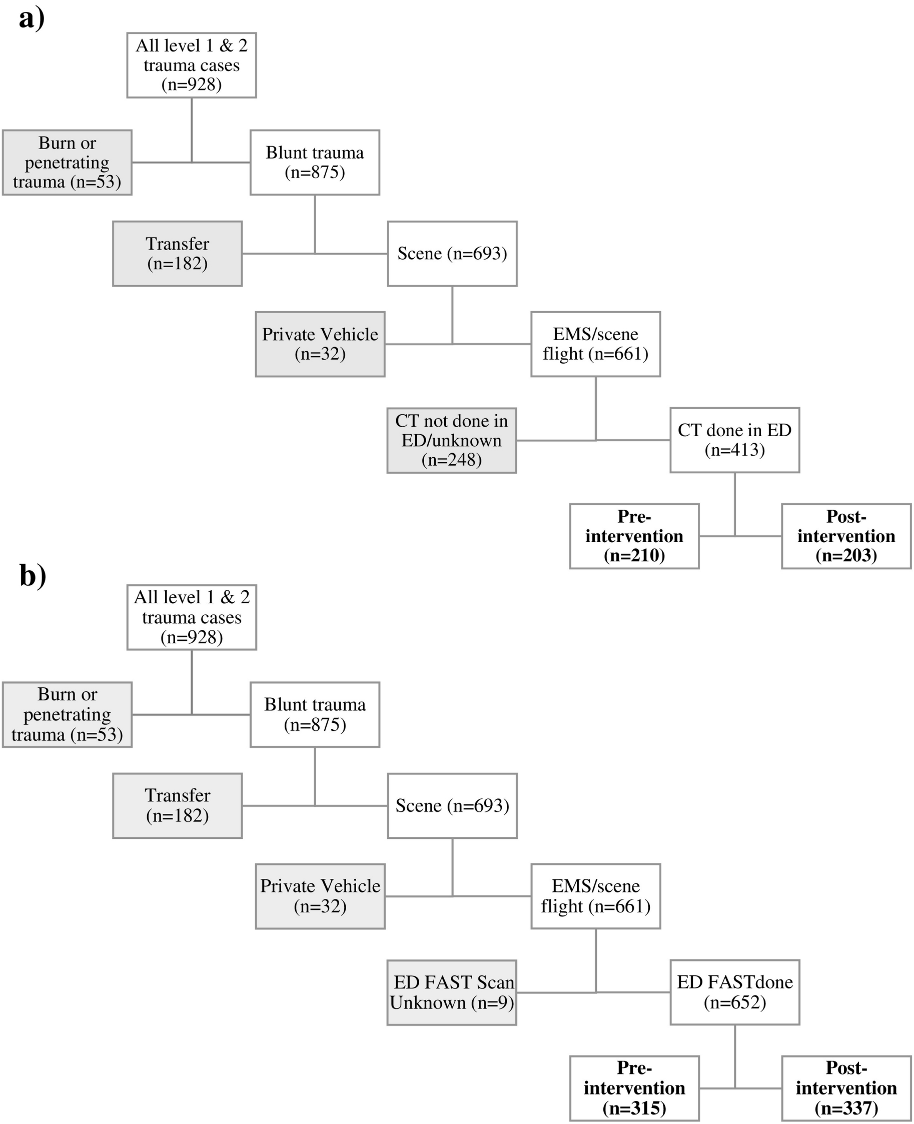
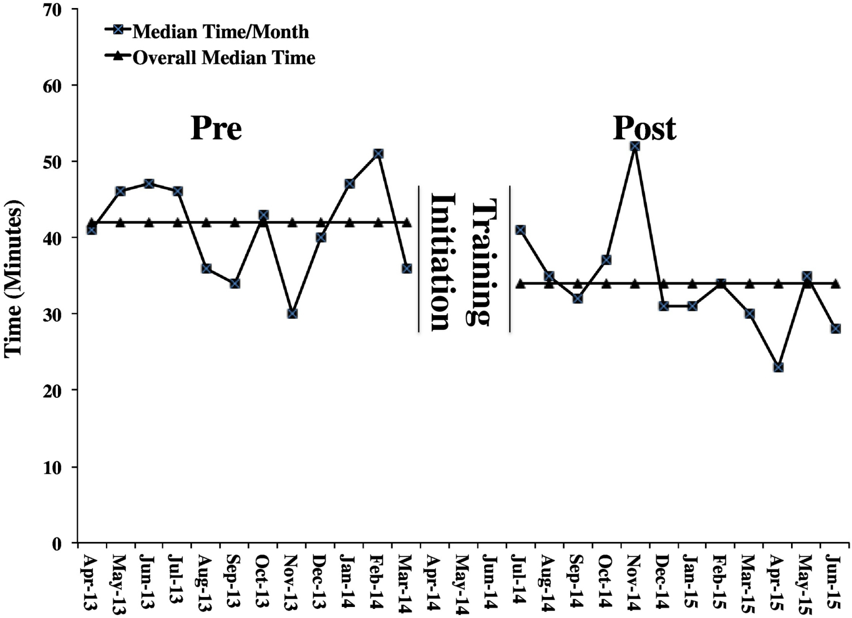

a)
All level 1 & 2 trauma cases (n=928)
Burn or penetrating trauma (n=53)
Blunt trauma (n=875)
Transfer (n=182)
Scene (n=693)
Private Vehicle (n=32)
EMS/scene flight (n=661)
CT not done in ED/unknown (n=248)
CT done in ED (n=413)
Pre-intervention (n=210)
Post-intervention (n=203)
b)
All level 1 & 2 trauma cases (n=928)
Burn or penetrating trauma (n=53)
Blunt trauma (n=875)
Transfer (n=182)
Scene (n=693)
Private Vehicle (n=32)
EMS/scene flight (n=661)
ED FAST Scan Unknown (n=9)
ED FASTdone (n=652)
Pre-intervention (n=315)
Post-intervention (n=337)

Figure 1



70
60
50
40
30
20
10
0
Time (Minutes)
Median Time/Month
Overall Median Time
Pre
Post
Training Initiation
Apr-13
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
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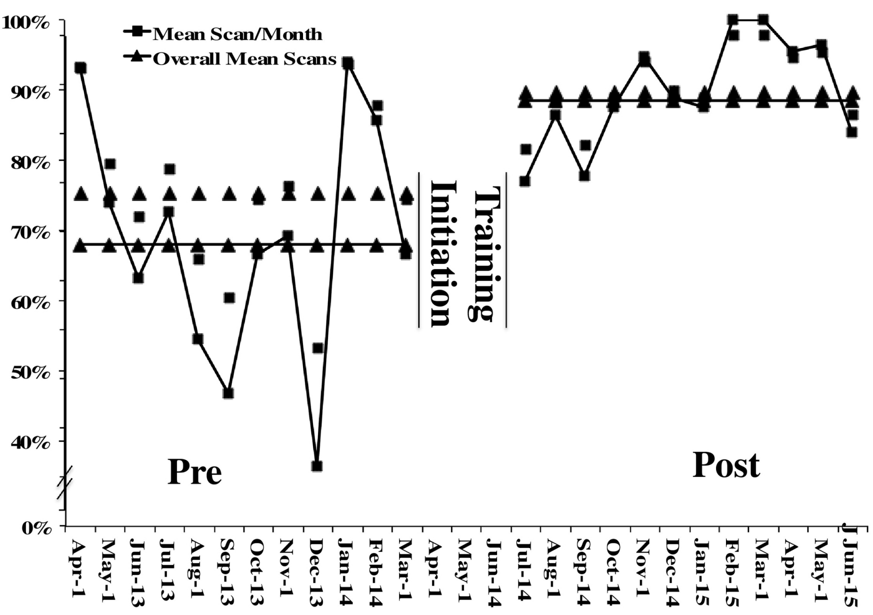
Figure 2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80%
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Mean Scan/Month
Overall Mean Scans
Training
Initiation
Pre
Post
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May-1
Jun-13
Jul-13
Aug-1
Sep-13
Oct-13
Nov-1
Dec-13
Jan-14
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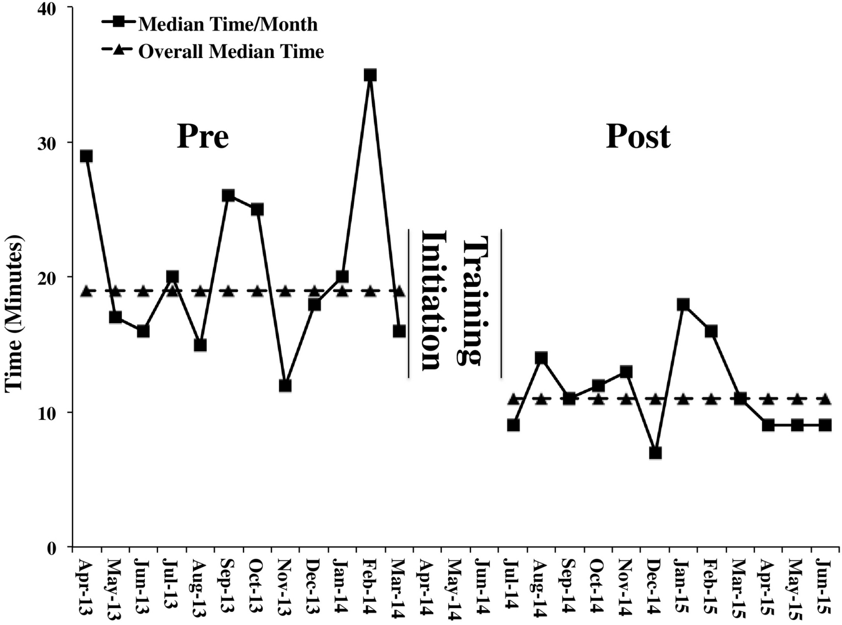
Jun-15

Figure 3


Median Time/Month
Overall Median Time
Pre
Post
Training
Initiation
Time (Minutes)
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10
20
30
40
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May-13
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Aug-13
Sep-13
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Figure 4